PERMANENT-MAGNET ELECTRIC MOTOR FOR CIRCULATION PUMPS OF HEATING SYSTEMS

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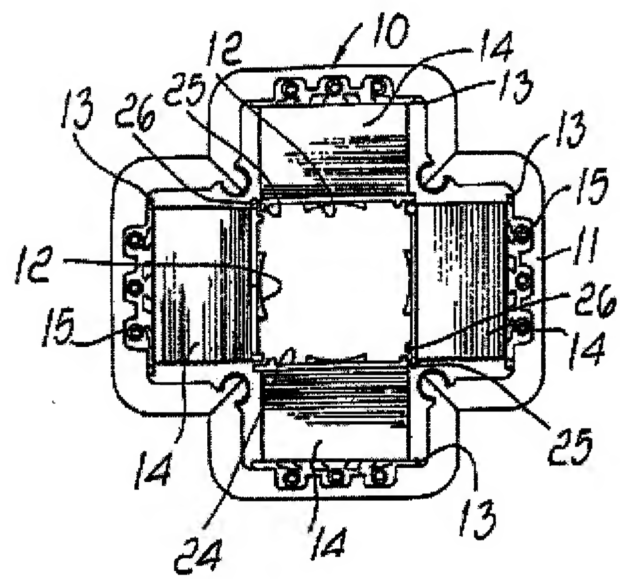
A permanent-magnet electric motor for circulation pumps of heating systems, comprising a stator (10) composed of a pack of metallic laminations (11) which form pole shoes (12) to which electrical windings (14) are coupled. A permanent-magnet rotor is arranged in a chamber which is separated with a watertight seal from the stator (10). The chamber that contains the rotor has a cross-section which is shaped so as to duplicate the contour of the pole shoes (12) in regions affected by the pole shoes (12) and so as to form wider portions in regions that are not affected by the pole shoes (12).



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(54) **PERMANENT-MAGNET ELECTRIC MOTOR FOR CIRCULATION PUMPS OF HEATING SYSTEMS**

PERMANENTMAGNETELEKTROMOTOR FÜR UMWÄLZPUMPEN FÜR HEIZUNGSANLAGEN

MOTEUR ELECTRIQUE A AIMANT PERMANENT, DESTINE A DES POMPES DE CIRCULATION DE SYSTEMES DE CHAUFFAGE

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- **PATENT ABSTRACTS OF JAPAN vol. 008, no. 226 (E-272), 17 October 1984 (1984-10-17) & JP 59 106843 A (MITSUBISHI DENKI KK), 20 June 1984 (1984-06-20)**

EP 1 281 229 B1

Description

Technical field

[0001] The present invention relates to a permanent-magnet electric motor for circulation pumps of heating systems.

Background art

[0002] The circulation pumps of heating systems are currently substantially constituted by a centrifugal pump coupled to an asynchronous electric motor.

[0003] The stator is substantially composed of a toroidal lamination pack to which electric windings are coupled.

[0004] The rotor is constituted by a shaft and by a lamination pack to which the shaft is coupled.

[0005] The lamination pack accommodates a squirrel-cage circuit.

[0006] The rotor is immersed in a fluid to be forced into the system and therefore, in order to avoid corrosion of the metallic parts, particularly of the lamination pack (since the conductors of the squirrel-cage circuit are made of copper), the rotor is protected by means of a stainless steel jacket.

[0007] The rotor is arranged in a cylindrical chamber which is separated with a watertight seal from the stator and is usually formed by a metallic tubular element.

[0008] It is known that for good operation of asynchronous motors, the gap between the rotor and the stator must be reduced to a minimum.

[0009] In known motors, the gap has minimum limits which are constituted in practice by the thickness of the metallic tubular element forming the rotation chamber of the rotor, by the stainless steel jacket protecting the rotor, and by the space required (mainly dependent on machining tolerance) between the rotor and the tubular element.

[0010] The fundamental need to minimize the gap in circulation pumps of heating systems, however, clashes with the need to adequately dissipate the heat produced by the stator windings, bearing also in mind that the temperature of the circulation water can be as high as 95°C.

[0011] The rotor is immersed in water due to the connection of its chamber to the chamber of the impeller, but the fluid film that forms between the rotor and the walls of the chamber is too small to allow an adequate heat exchange between the stator and the water.

[0012] Furthermore, the fact that the space between the rotor and the chamber is inevitably limited entails the real possibility of rotor jamming, mainly due to dirt which can infiltrate into the empty spaces.

[0013] Another consequence is insufficient evacuation of the air bubbles that form especially during the installation and filling of the hydraulic circuit and subsequently when the pressure increases due to the temperature.

[0014] The presence of air inside the pump is annoying because it generates noise and most of all may seriously compromise the duration of the bushes that support the rotor shaft.

[0015] For this reason, known motors have a vent screw placed in the rear part of the rotor chamber.

[0016] The screw is also meant to release the rotor when dirt prevents it from rotating.

[0017] Furthermore, the fact that the element for separating the fluid circulating in the rotor chamber and the active parts of the stator (iron, copper) is made of a material which is not electrically insulating forces the manufacturer to ground the electric circuit, with obvious constructive complications which affect costs.

[0018] In document DE 195 18215 A a pump with a motor having a permanent magnet rotor is disclosed, which is insulated from the stator. The pump has the features set out in the preamble of claim 1.

Disclosure of the Invention

[0019] The aim of the present invention is to provide an electric motor for circulation pumps of heating systems having such a structure which allows to eliminate or substantially reduce the problems noted above in conventional motors.

[0020] Within the scope of the above aim, a consequent primary object of the invention is to provide a motor which is compact and constructively solid.

[0021] Another important object is to provide an electric motor having a structure which is capable of providing good heat dissipation into the environment.

[0022] Another object of the invention is to provide a motor whose structure can integrate a plurality of components and therefore achieves considerable benefits in terms of simplicity of assembly.

[0023] Another object of the invention is to provide a motor having a structure which is competitive with respect to conventional motors also from the point of view of costs.

[0024] This aim and these and other objects which will become better apparent hereinafter are achieved by a permanent-magnet electric motor for circulation pumps of heating systems according to the invention comprising the features set forth in claim 1.

[0025] Advantageously, the cross-section of said chamber that contains the rotor is substantially square, with central regions of the sides which widen in an arc-like shape.

Brief description of the drawings

[0026] Further characteristics and advantages of the invention will become better apparent from the detailed description of some embodiments thereof, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a side view of a circulation pump provided with the motor according to the invention in a first embodiment;

Figure 2 is a sectional view, taken along a longitudinal plane, of the stator of the motor of Figure 1;

Figure 3 is a plan view of the chamber in which the rotor is placed;

Figure 4 is a front view of the stator pole shoes with the respective windings;

Figure 5 is an enlarged-scale perspective view of a detail of Figure 4;

Figure 6 is a general perspective view of the pole shoes of Figure 4;

Figure 7 is a sectional view, taken along a longitudinal plane, of the assembled stator in a second embodiment of the motor;

Figure 8 is a sectional view of the components of the stator of Figure 7;

Figure 9 is a sectional view, taken along a longitudinal plane, of the assembled stator in a third embodiment.

Ways of carrying out the Invention

[0027] With reference to the above cited Figures 1 to 6, a permanent-magnet electric motor for circulation pumps of heating systems having the structure according to the invention comprises, in a first embodiment, a stator 10 which is composed of a pack of metallic laminations 11 which form four pole shoes 12 arranged in a cross-shaped configuration; corresponding spools 13 made of plastic are coupled to the pole shoes and support respective windings 14, each of which is provided with electrical connection terminals 15.

[0028] The motor further comprises a permanent-magnet rotor 16 arranged in a chamber 17 which is separated with a watertight seal from the stator 10.

[0029] As shown in the figures, an impeller 8 is keyed at one end to a shaft 16a of the rotor 16, and is arranged in a volute 19 which is coupled to the motor so as to constitute a circulation pump 20.

[0030] At this point it should be noted that the lamination pack 11 and the spools 13 with the windings 14 are embedded and insulated in a plastic enclosure 21 which is molded in place and integrates a chamber 17 of the rotor 16.

[0031] As shown in the figures, the only elements protruding from the enclosure 21 are the electrical connection terminals 15.

[0032] Furthermore, the chamber 17 has a particular contour which duplicates the circular shape of the pole shoes 12 in regions 22 affected thereby and instead has wider portions 23 in the unaffected regions.

[0033] In practice, the cross-section of the chamber 17 is substantially square, with arc-shaped wider portions of the sides in the central regions.

[0034] In a permanent magnet synchronous motor it is in fact possible to widen the spaces in the regions not affected by the pole shoes, so as to increase the amount of fluid that can penetrate between the rotor 16 and the internal wall of the chamber 17 in order to increase the heat exchange between the fluid and the stator 10.

[0035] Reducing the amount of space in which the rotor 16 is adjacent to the chamber 17 also reduces the danger of jamming of the rotor 16 and facilitates the escape of any air bubbles which might have been trapped inside the chamber 17 of the rotor 16.

[0036] It should also be noted (see in particular Figures 3 and 4) that the spools 13 that support the windings 14 of the stator 10 have ends 24 located on the rotor side 16 which are each shaped so as to form a raised portion 25 at one side and a complementarily shaped recess 26 at the other side, so that in the cross-shaped arrangement they abut for mutual positioning so as to avoid movements during the injection-molding of the enclosure 21.

[0037] With reference now to the above cited Figures 7 and 8, in a second embodiment the motor is again composed of a stator 110 with a pack of laminations 111 which form pole shoes 112 to which spools 113 are coupled for windings 114 with respective electrical connection terminals 115.

[0038] The rotor is again provided and is arranged in a chamber 117 which is separated with a watertight seal from the stator 110; in this case, however, the molded-in-place enclosure 121 which includes the pole shoes 112 and the electrical windings 114 does not integrate the rotor chamber, which is instead provided by means of a separate component 117 which is inserted in a corresponding space 127 and couples by interlocking with a flanged part 128 thereof provided with male tabs 129 to be inserted in adapted seats 130 of the enclosure 121.

[0039] The cross-section of the chamber 117 is equivalent to the cross-section of the already mentioned chamber 17.

[0040] Watertightness against possible infiltrations of water which might occur in the region for the coupling of an abutment 131 of the flange 128 and a plane 132 of the stator 110 (moisture, tube dripping, et cetera) can be ensured by ultrasound welding, gluing, or by providing a gasket.

[0041] The pole shoes 112 are thus protected.

[0042] With reference to the above cited Figure 9, in a third embodiment the motor is again composed of a stator 210 with a pack of laminations 211 which form pole shoes 212 to which spools 213 are coupled for windings 214 with respective electrical connection terminals 215.

[0043] The rotor is again provided and is arranged in a chamber 217 which is separated with a watertight seal from the stator 210.

[0044] It should be noted that the lamination pack 211 and the spools 213 with the windings 214 are embedded in an epoxy resin inside an enclosure 221 made of plastic, which integrates the chamber 217 of the rotor.

[0045] In practice it has been found that all the above

embodiments of the electric motor for circulation pumps of heating systems achieve the intended aim and objects of the present invention.

[0046] The particular shape of the stator of the synchronous motor in fact allows to fully utilize the region of heat exchange between the rotor and the water that circulates in the rotor chamber, which is conveniently provided with a non-circular cross-section with a widened space for circulation of the fluid between the chamber and rotor.

[0047] The reduction of the regions in which the rotor is adjacent to the internal surface of the chamber reduces the possibility of jamming of the rotor due to dirt.

[0048] This fact, combined with a rotor/chamber clearance of approximately 0.5 mm, allows to eliminate the screw which is usually located on the side of the pump that is connected to the rotor chamber in conventional circulators and that, in case of jamming, is removed to allow the operator to act on the shaft (which has notched ends) with a screwdriver so as to release the rotor.

[0049] It should also be noted that the synchronous motor has a higher starting torque than the traditional asynchronous motor, so that if jamming unfortunately occurs, it has a better chance of overcoming the contrasting friction torque.

[0050] The enlargement of the space between the rotor and the chamber, in which the circulating fluid is usually at a pressure of 2/3 bar in normal operating conditions, allows natural and almost automatic degassing, without requiring operations to be performed from the outside.

[0051] The motor, produced by means of a monoblock unit constituted by the molded-in-place stator, is furthermore particularly compact and strongly built; electrical insulation and resistance to moisture being also ensured.

[0052] The active parts of the motor, made of iron and copper, are electrically insulated from the water, since the part that constitutes the separator is made of plastics. It is therefore unnecessary to electrically ground the device.

[0053] The stator windings embedded in plastic without air gaps also produce good motor/environment heat dissipation.

[0054] Finally, attention is called to the possibility of integrating several components, with considerable benefits in terms of ease of assembly.

[0055] In particular, the terminals 15 of the windings 14 are kept perfectly in position in the mold, so that the control electronics can be assembled without particular techniques.

[0056] The invention thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the appended claims.

[0057] All the details may furthermore be replaced with other technically equivalent elements.

[0058] In practice, the materials employed, so long as they are compatible with the contingent use, as well as the dimensions, may be any according to requirements.

[0059] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. A permanent-magnet electric motor for circulation pumps of heating systems, comprising:

   a stator (10, 110, 210) composed of a pack of metallic laminations (11, 111, 211) which form pole shoes (12, 112, 212) to which electrical windings (14, 114, 214) are coupled;
   a permanent-magnet rotor (16), arranged in a chamber (17, 117, 217) separated with a watertight seal and electrically insulated from the stator;

   wherein said chamber (17, 117, 217) that contains the rotor (16) has a cross-section which duplicates the circular shape of the pole shoes in regions (22) of said chamber (17, 117, 217) affected by said pole shoes (12, 112, 212) and is shaped so as to form wider portions (23) in regions that are not affected by said pole shoes (12, 112, 212).
   characterised in that:

   the stator (10, 110, 210) is composed of four pole shoes arranged in a cross-shaped configuration; and
   the cross-section of the chamber (17) is substantially square, with corner portions forming said wider portions (23) in regions that are not affected by said pole shoes and with arc-like portions (22) in central regions of the sides, said central regions being said regions (22) of said chamber (17) affected by said pole shoes (12).

2. The motor according to claim 1, **characterized in that** said metal lamination pack (11, 111, 211) that forms the pole shoes (12, 112, 212) and the corresponding electric windings (14, 114, 214) are embedded and insulated in a plastic enclosure (21, 121, 221) which is molded in place.

3. The motor according to claim 2, **characterized in that** said enclosure (21, 221) integrates said chamber (17, 217) in which said permanent-magnet rotor (16) is arranged.

4. The motor according to claim 2, **characterized in that** said chamber (117) in which said rotor (16) is arranged is formed by a plastic component (117) added to said enclosure (121) that embeds said pack of laminations and the corresponding electrical windings, said additional component (117) being assembled with said enclosure (121) by interlocking.

5. The motor according to claim 4, **characterized in that** said plastic component (117) forms said chamber (117) in which the rotor is arranged and includes a flanged part (128) which couples by interlocking with said enclosure.

6. The motor according to claim 5, **characterized in that** said plastic component (117) is associated, with a hydraulic seal, with said flanged part by means of a gasket or by ultrasonic welding, gluing or equivalent methods.

7. The motor according to claim 5, **characterized in that** said plastic component is associated, with a hydraulic seal, with said flanged part by molding-in-place of said additional component with said stator.

8. The motor according to claim 7, **characterized in that** complementary male and female interlocking components (129, 130) are formed between said flanged part and said enclosure.

9. The motor according to one or more of the preceding claims, **characterized in that** said pack of laminations (11, 111, 211) and spools (13, 113, 213) with the windings (14, 114, 214) are embedded in an epoxy resin inside a plastic enclosure (21, 121, 221) which integrates said rotor chamber (17, 117, 217).

10. The motor according to one or more of the preceding claims, wherein said windings are placed on four spools which are coupled to corresponding ones of said four pole shoes, **characterized in that** rotor-side ends of said spools have a raised portion (25) at one side and a complementary recess (26) at an other side for coupling and mutual positioning.

Patentansprüche

1. Elektrischer Motor mit Permanentmagneten für Umwälzpumpen von Heizsystemen, der folgendes umfasst:

    einen Ständer (10, 110, 210), der aus einem Paket von Metallblechen (11, 111, 211) zusammengesetzt ist, das Polschuhe (12, 112, 212) bildet, an denen elektrische Wicklungen (14,114,214) angebracht sind;

    einen Läufer (16) mit Permanentmagneten, der in einer Kammer (17, 117, 217) angeordnet ist, die mit einem wasserdichten Verschluss abgetrennt ist und elektrisch vom Ständer isoliert ist;

    wobei die Kammer (17, 117, 217), die den Läufer (16) enthält, einen Querschnitt aufweist, der die kreisförmige Form der Polschuhe in Regionen (22) der Kammer (17, 117, 217) wiedergibt, die von den Polschuhen (12, 112, 212) berührt werden, und die so geformt ist, dass sie geweitete Abschnitte (23) in den Regionen bildet, die nicht von den Polschuhen (12, 112, 212) berührt werden,
    dadurch gekennzeichnet, dass
    der Ständer (10, 110, 210) aus vier Polschuhen zusammengesetzt ist, die in einer kreuzförmigen Konfiguration angeordnet sind; und
    der Querschnitt der Kammer (17) im Wesentlichen quadratisch ist, mit Eckbereichen, welche die geweiteten Abschnitte (23) in den Regionen bilden, die nicht von den Polschuhen berührt werden, und mit bogenartigen Abschnitten (22) in mittleren Regionen der Seiten, wobei die mittleren Regionen die Regionen (22) der Kammer (17) sind, die von den Polschuhen (12) berührt werden.

2. Motor nach Anspruch 1, **dadurch gekennzeichnet, dass** das Blechpaket (11, 111, 211), das die Polschuhe (12, 112, 212) bildet, und die entsprechenden elektrischen Wicklungen (14, 114, 214) in eine Kunststoffkapselung (21, 121, 221) eingebettet und isoliert sind, welche übergeformt ist.

3. Motor nach Anspruch 2, **dadurch gekennzeichnet, dass** die Kapselung (21, 221) die Kammer (17, 217) integriert, in welcher der Läufer (16) mit Permanentmagneten angeordnet ist.

4. Motor nach Anspruch 2, **dadurch gekennzeichnet, dass** die Kammer (117), in welcher der Läufer angeordnet ist, durch eine Kunststoffkomponente (117) gebildet wird, die der Kapselung (121) angefügt wird, die das Blechpaket und die entsprechenden elektrischen Wicklungen einbettet, wobei die zusätzliche Komponente (117) mit der Kapselung (121) durch Ineinandergreifen zusammengebaut wird.

5. Motor nach Anspruch 4, **dadurch gekennzeichnet, dass** die Kunststoffkomponente (117) die Kammer (117) bildet, in welcher der Läufer angeordnet ist, und eine geflanschte Partie (128) enthält, die sich durch Eingreifen mit der Kapselung verbindet.

6. Motor nach Anspruch 5, **dadurch gekennzeichnet, dass** die Kunststoffkomponente (117) hydraulisch verschließend mit der geflanschten Partie mit-

tels einer Dichtung oder mittels Ultraschallschweißen, Kleben oder gleichwertiger Methoden verbunden ist.

7. Motor nach Anspruch 5, **dadurch gekennzeichnet, dass** die Kunststoffkomponente (117) hydraulisch verschließend mit der geflanschten Partie mittels Überformen der zusätzlichen Komponente mit dem Läufer verbunden ist.

8. Motor nach Anspruch 7, **dadurch gekennzeichnet, dass** komplementäre männliche und weibliche ineinandergreifende Komponenten (129, 130) zwischen der geflanschten Partie und der Kapselung ausgebildet sind.

9. Motor nach einem oder mehreren der voranstehenden Ansprüche, **dadurch gekennzeichnet, dass** das Blechpaket (11, 111, 211) und die Spulen (13, 113, 213) mit den Wicklungen (14, 114, 214) in ein Epoxidharz innerhalb einer Kunststoffkapselung (21, 121, 221) eingebettet sind, das die Läuferkammer (17, 117, 217) integriert.

10. Motor nach einem oder mehreren der voranstehenden Ansprüche, wobei die Wicklungen auf vier Spulen plaziert sind, die mit den entsprechenden der vier Polschuhe verbunden sind, **dadurch gekennzeichnet, dass** diese Läuferseitenenden dieser Spulen zur Verbindung und gegenseitigen Positionierung an einer Seite einen erhabenen Abschnitt (25) und eine komplementäre Aussparung (26) an der anderen Seite aufweisen.

Revendications

1. Moteur électrique à aimant permanent pour les pompes de circulation des systèmes de chauffage, comprenant :

   - un stator (10, 110, 210) composé d'un ensemble de lamelles métalliques (11, 111, 211) formant des pièces polaires (12, 112, 212) auxquelles des bobinages électriques (14, 114, 214) sont reliés,
   - un rotor (16) à aimant permanent, disposé dans une chambre (17, 117, 217) séparée par un joint imperméable à l'eau et isolée électriquement du stator,

   où ladite chambre (17, 117, 217) contenant le rotor (16) présente une section transversale qui copie la forme circulaire des pièces polaires dans les régions (22) de ladite chambre (17, 117, 217) affectées par lesdites pièces polaires (12, 112, 212) et est conformée de façon à former des portions plus larges (23) dans les régions qui ne sont pas affectées par lesdites pièces polaires, **caractérisé en ce que** :

   - le stator (10, 110, 210) est composé de quatre pièces polaires disposées en une configuration en croix, et
   - **en ce que** la section transversale de la chambre (17) est essentiellement carrée, avec des portions de coin formant lesdites portions plus larges (23) dans les régions qui ne sont pas affectées par lesdites pièces polaires et avec des portions en forme d'arcs (22) dans les régions centrales des côtés, lesdites régions centrales étant lesdites régions (22) de ladite chambre (17) affectées par lesdites pièces polaires (12).

2. Moteur selon la revendication 1, **caractérisé en ce que** ledit paquet de lamelles métalliques (11, 111, 211) qui forme les pièces polaires (12, 112, 212) et les bobinages électriques (14, 114, 214) correspondants sont enrobés et isolés dans une enceinte plastique (21, 121, 221) qui est moulée sur place.

3. Moteur selon la revendication 2, **caractérisé en ce que** ladite enceinte (21, 221) intègre ladite chambre (17, 217) dans laquelle ledit rotor à aimant permanent est disposé.

4. Moteur selon la revendication 2, **caractérisé en ce que** ladite chambre (117) dans laquelle ledit rotor est disposé est formée par un composant plastique (117) ajouté à ladite enceinte (121) qui enrobe ledit paquet de lamelles métalliques et les bobinages électriques correspondants, ledit composant additionnel étant assemblé avec ladite enceinte (121) par enclenchement.

5. Moteur selon la revendication 4, **caractérisé en ce que** ledit composant plastique (117) forme ladite chambre (117) dans laquelle le rotor est disposé et inclut une partie (128) munie d'un rebord qui s'accroche à ladite enceinte par enclenchement.

6. Moteur selon la revendication 5, **caractérisé en ce que** ledit composant plastique (117) est accroché, par un joint hydraulique, à ladite partie munie d'un rebord au moyen d'un manchon ou par soudure par ultrasons, collage ou des méthodes équivalentes.

7. Moteur selon la revendication 5, **caractérisé en ce que** ledit composant plastique est associé, avec un joint hydraulique, à ladite partie munie d'un rebord par moulage en place dudit composant additionnel avec ledit stator.

8. Moteur selon la revendication 7, **caractérisé en ce que** des composants d'enclenchement mâles et femelles complémentaires (129, 130) sont formés en-

tre ladite partie munie d'un rebord et ladite enceinte.

9. Moteur selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit paquet de lamelles (11, 111, 211) et les bobines (13, 113, 213) avec les bobinages (14, 114, 214) sont enrobés dans une résine époxy dans une enceinte plastique (21, 121, 221) qui intègre ladite chambre du rotor (17, 117, 217).

10. Moteur selon l'une quelconque des revendications précédentes, où lesdits bobinages sont placés sur quatre bobines qui sont couplées auxdites quatre pièces polaires, **caractérisé en ce que** les extrémités desdites bobines du côté du rotor présentent une portion surélevée (25) sur un côté et un creux complémentaire (26) sur un autre côté pour le couplage et le positionnement mutuel.

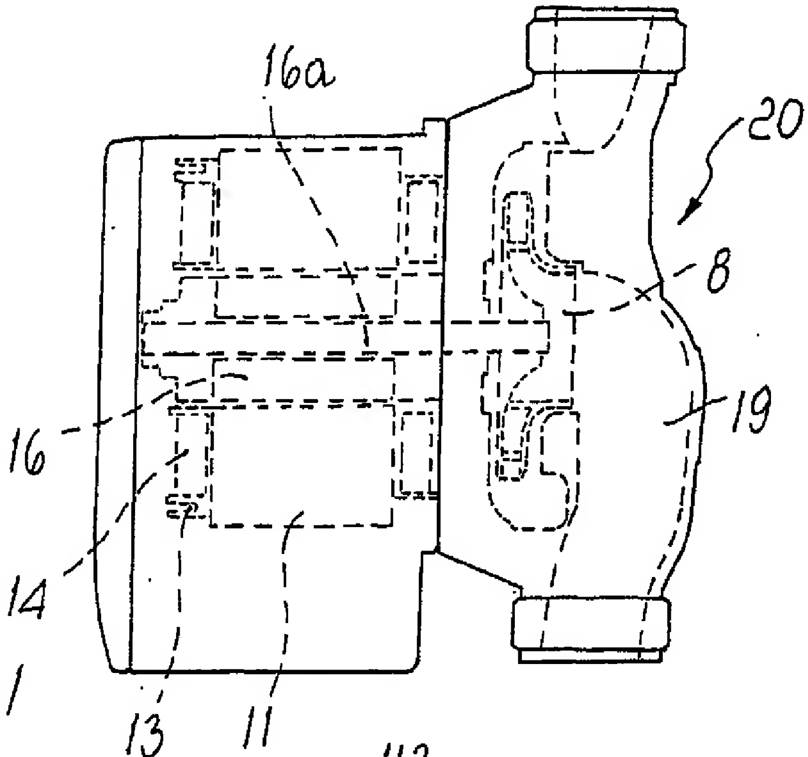


Fig.1

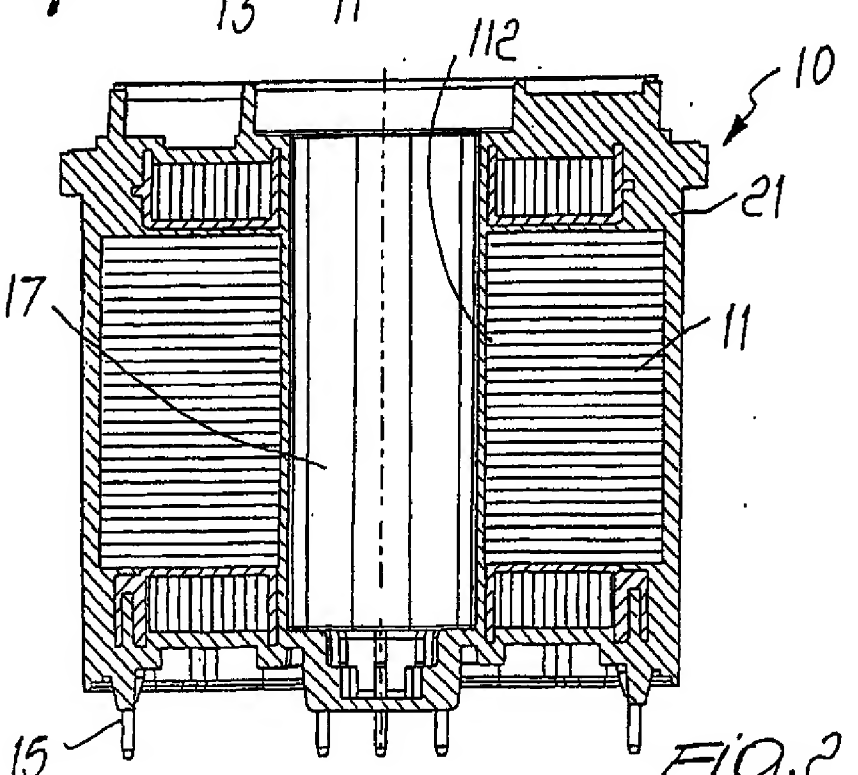


Fig.2

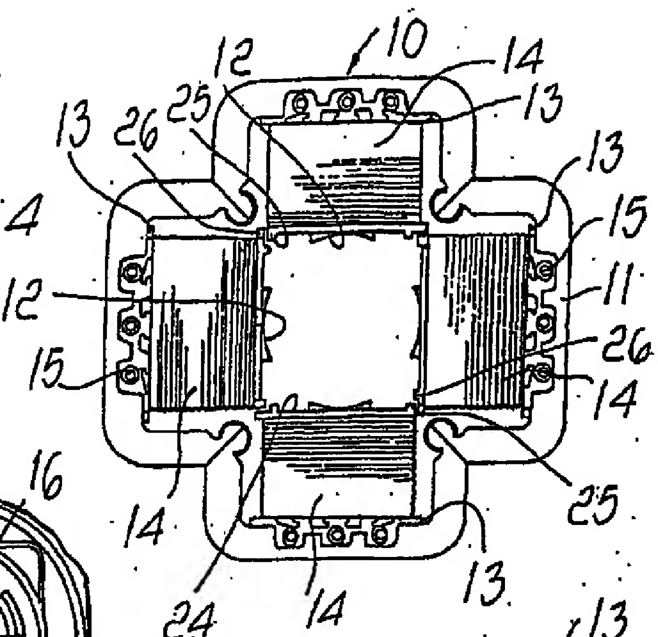


Fig. 4

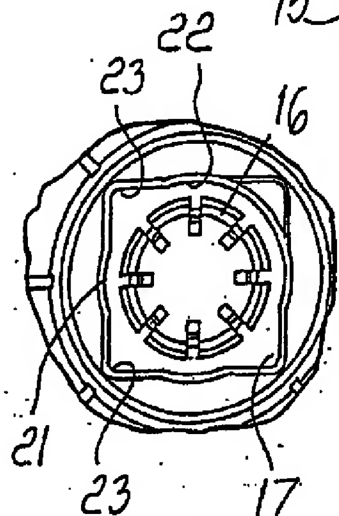


Fig. 3

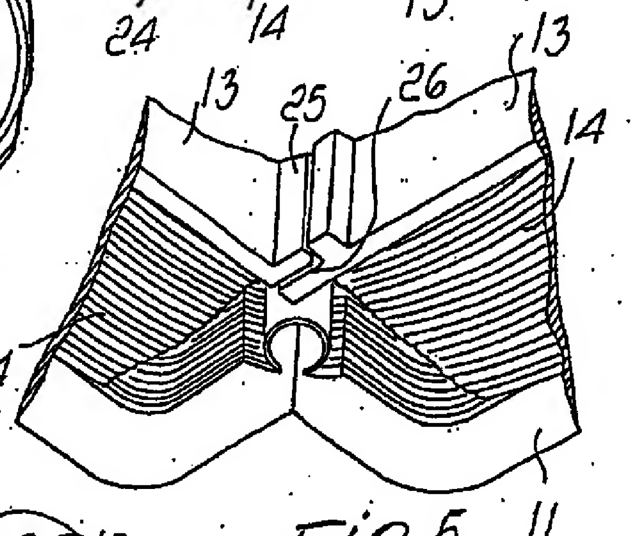


Fig. 5

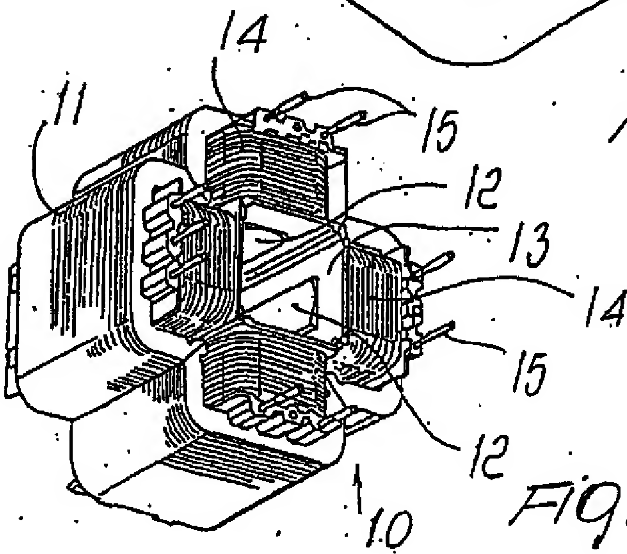
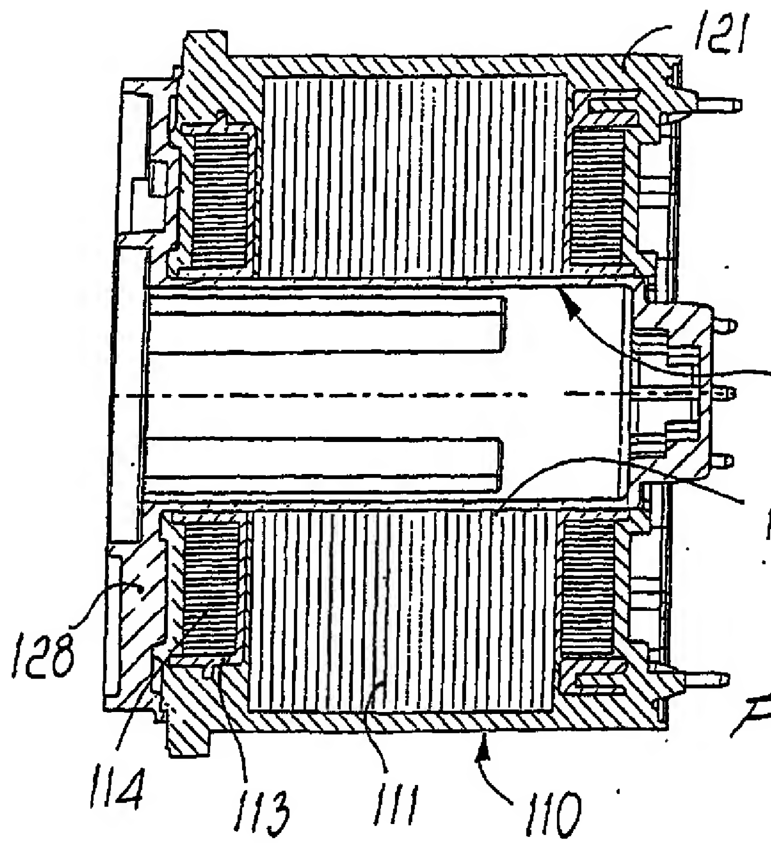


Fig. 6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113
111
110

Fig.7

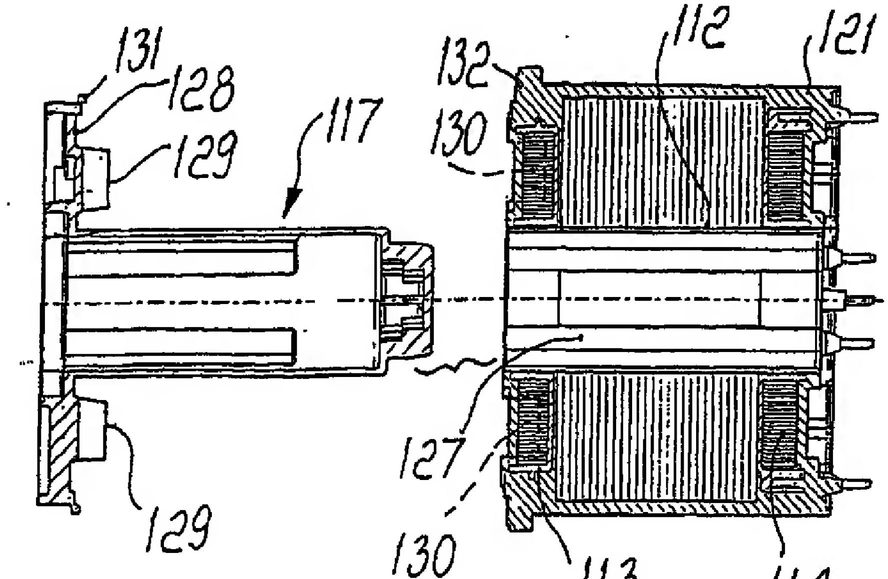
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Fig.8

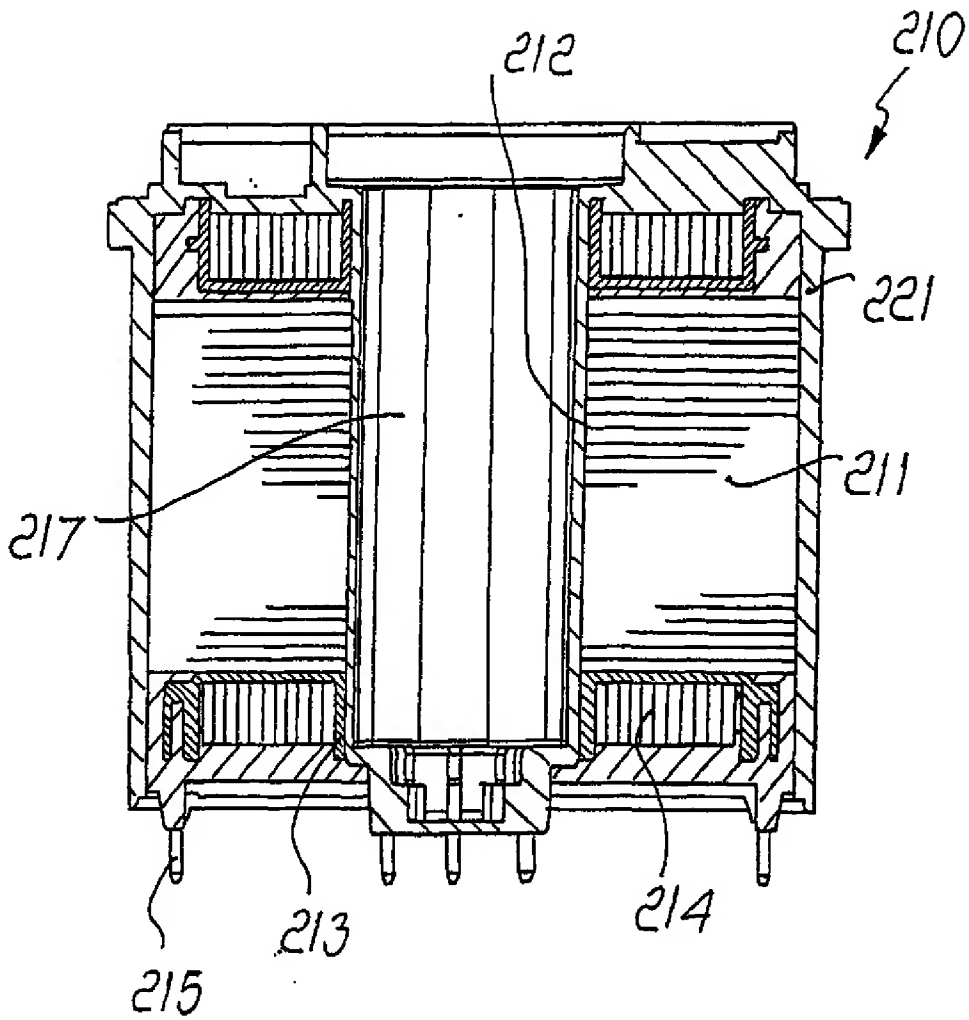

Fig. 9